QUANTUM-NOISE-LIMITED CAVITY RING-DOWN SPECTROSCOPY IN THE MID-INFRARED

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We report a highly sensitive mid-infrared spectrometer capable of recording cavity ring-down events in the quantum (shot) noise limit. A linear optical cavity of finesse 31,000 was pumped by a distributed feedback quantum cascade laser (DFB-QCL) operating at 4.5 μm until a cavity transmission threshold was reached. A fast optical switch then extinguished optical pumping and initiated a cavity decay which exhibited root-mean-square noise proportional to the square root of optical power (quantum noise) for several cavity time constants until a detector noise floor was reached. This spectrometer has achieved a noise-equivalent absorption of NEA = 2.6×10^{-11} $\mathrm{cm}^{-1}\mathrm{Hz}^{-1/2}$ and a minimum absorption coefficient of $\alpha = 2.3 \times 10^{-11}$ cm^{-1}in 3 seconds. Applications for such a highly sensitive spectrometer operating in the mid-infrared region, including ultra-trace molecular spectroscopy of CO_2 isotopologues and the direct interrogation of weak mirror birefringence and polarization-dependent losses, will be discussed.